PATHOLOGICAL STUDIES ON RICE BLAST CAUSED BY PIRICULARIA ORYZAE

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- JAPAN -

PART III PATHO-HISTOLOGICAL OBSERVATIONS OF DISEASED PLANTS

I. External Observation

The size of spots of piricularia oryzae is not fixed. They first
appear as small watery spots which gradually turn brown as they are
exposed to sunlight. Most of them are elliptical or spindle-shaped
but sometimes they are seen as elongated spots. Spots which are
joined are conglutinated into one large, irregular spot. The center
of the large spot is greyish white, dark grey, or liver coloured,
is mostly desiccated and sometimes broken. It is surrounded by a
dark brown band. The outer perimeter of this dark band is light
yellow and this section becomes more indistinct the further it is
separated from the center of the spot and ultimately moves into
healthy portions, and its border is indistinct (Fig. 1, A, B). While
the spots usually are long and spindle shaped, a yellow-brown line
is frequently detected coming out of the spindle along the vascular
bundle which runs along the spotted section. (Fig. 1C) Sometimes
the spot will stop growing while it is still small and it will appear
that at least that particular section had healed. This condition
is governed by the variety of rice plant, environment in which
cultivated, etc. This should be viewed as a type of suspicious
lignification /sic/ of the damaged surrounding tissue, and is the
result of repressing later damage by fungus. However, the so-called
healed layer is not seen in the rice plant and it is frequently
advisable not to consider it as completely healed in view of the

above. Frequently it becomes impossible to prevent the spread of the diseased portion after the pathogenes have invaded the deep tissue.

In the case of the stem, i.e. when the ear or node is attacked by piricularia oryzae, the spots at first are the same as on the leaf, and very small brown spots grow on the surface of one side. However, after the pathogenes invade the deep tissue, the degree of internal infection becomes severe and therefore, after the disease has broken out, long, tubular brown stripes are seen around the stem.

In the damage done to the stem, one very frequently sees an attack on the base of the ear and the node section of the spikelets. This may probably be due to the fact that pathogenic spores may easily settle on the outside of the node, which has a complex configuration. By complex configuration is meant branching of the spikelets, antler-like hairs at the branching point, and scaly bracts in the ear section.

II. Internal Observations

a. Piricularia Oryzae in the Leaf

The materials used in this experiment were Togo and Early Jinriki leaves, attacked by Piricularia Oryzae, which were grown naturally on the grounds of Kyushu University in 1932. They were fixed in weak chrome acetate and desilicified in an aquatic solution of hydrogen fluoride after being washed in water. The materials were placed in paraffin and generally 6-12 μ cross sections were made. They were examined microscopically after dyeing in HAIDENHEIN haematoxylin-eosin, methyl green-ruthenium red, methyl green-acid fuchsin, gentian violet-safranin. Sometimes longitudinal sections and flat sections of the leaf surface were made to supplement inadequacies in observation of cross sections.

The afflicted tissue should be classified into (1) disintegrated, (2) necrotic, and (3) venenate (semi-necrotic) (Fig. 2A). When these types are observed from the outside, the disintegrated tissue displays a greyish white or yellow-brown color in the center of the spots, and in the section which is clearly withered and desiccated, the formation of pathogenic basidiospicae and conidiospores is frequently observed. The necrotic section in many cases is the part surrounding the outer edge of the disintegrated section. Here the coloration is darkest and is liver-colored. When the spots are closely examined, a part is frequently seen which should be recognized as disintegrated,

in the vascular bundle and its surrounding tissue within the area
of the disintegrated section. The venenate section when observed
from the outside is that part which, inside the spot, is outside
of the liver-colored band. It presents a light yellow green or
light yellow brown color, that is, it is that portion where the
leaf seems to be discolored. Usually this part is rather wide
and extends a considerable distance vertically. The border between
this part and the outer healthy part is indistinct.

Figure 1: Affected leaf blade.
           A. Beginning stage. B. Terminal stage. C. Indicates
           brown lines which run out of typical spindle-shaped
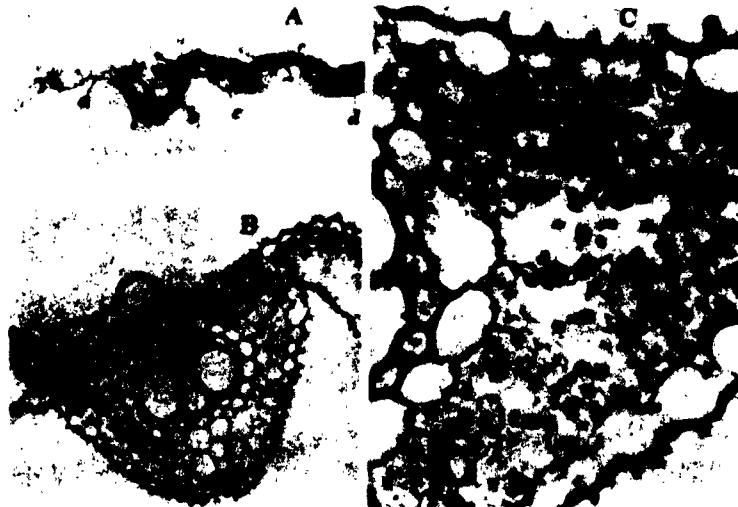   spots. C. is rather larger than A and B.

Figure 2: A. Infected leaf cross section. a. disintegrated
           section b. necrotic section c. venerate section
           d. healthy section. B. Venenate section with
           many hyphae in bast section, chloroplasts are reduced
           in size. C. expansion of venenate section.

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Disintegrated Section

There is a complete loss of matter inside of the cells and part of the membrane is gone. The remaining cells appear to be pressed from above and below, and their thickness is reduced. Consequently this appears as remaining tissue which has been pressed and dried out. Frequently rough brown hyphae are observed in the disintegrated assimilatory tissue. The stomata on the basidiospicae are forced open and usually are bunched together and pushed outwards, but sometimes emerge by tearing through the outer epidermal wall (Fig. 3D)

Figure 3: A. Venenate section on left, chloroplasts are

dissolved, necrotic section on right; B. Many hyphae inside
reticulate vessels, left is venenate, right is necrotic;
C. Venenate section, inside of cells granular, homogeneous,
disintegrated, hyphae visible inside sheath; D. Basidospicae
growing in disintegrated section; E. Expansion of venenate
section; Frothy disintegrated inside cells, many hyphae in
vessels and bundle sheathes.

Usually there are more hyphae in the vascular bundles
than in the assimilatory tissue. Generally there are more hyphae
in the assimilatory tissue near the vascular bundle than in that
which is located farther away.

Necrotic Section

This section can be seen slightly around the disintegrated
section, in and around the vascular bundle in the disintegrated
section or near the motor cells. (Fig. 2A, b, fig. 3, A,B). The
cell walls not yet severely disintegrated are brown and abundant
in chromatin. The contents of the cells either partially remain
or are completely gone. As a relic, one can see small deteriorated
chloroplasts and deteriorated nuclei. Many of these are located
in the folds of the brachial configured cells and the cell walls
likewise are either full of chromatin or have turned a natural brown
color. In the necrotic section a few rough brown hyphae are seen
in the section close to the disintegrated region. There are many
hyphae in the section near the venenate area. Sometimes hyphae
were not seen in the necrotic section. In such cases the latter
immediately is adjoined by the healthy area and there is no venenate
section.

Venenate Section

The term "venenate section" as used here refers collectively
to that portion in which no pronounced tissue deterioration is yet
visible although it has been invaded directly or indirectly by
pathogenes. The pathogenic hyphae can be seen not only in the assimi-
latory tissue, but in the epidermis, sometimes in the vascular
bundle, i.e., the cells in the vascular bundle sheath, in the sieve
tubes or vessels or in the parenchyma cells around them. Frequently,
on the other hand, there are no hyphae in the venenate section.

Sometimes many hyphae are detected only in one part of
the vessel in a cross section of the venenate area with none being
seen elsewhere. That is, in this case the vessel is invaded in other

parts by the fungi and the hyphae which have invaded rapidly elongate within the vessel. Thus we have indicated their existence only in the above mentioned vessel in one cross section. In such a case it is by no means unusual for there to be many more hyphae in the vessels than in the case of wilting caused by Fusarium (Fig. 3B). Also, in this case the assimilatory tissue around the invaded vascular bundle often indicates symptoms of venenation. Thus it (venenation) is seen not only in the vessels, but in the sieve tubes and in the tissue around the vascular bundle (Fig. 2B, Fig. 3, C, E). In these cases the piricularia oryzae infects the vascular bundle, and after this happens there is little resistance to the pathogenes and the infected section increases markedly. Such an increase in damage should be termed "internal infection." In the external observations of this disease already described, the yellowish brown lines running from the definite spindle-shaped spots in this manner grow along the vascular bundle and the pathogenetic mechanism is no different from that of the rust on wheat (6, 7).

The deterioration of diseased tissue, especially cell content in the venenate area is very complex. Sometimes the cell walls naturally became markedly brown in color.
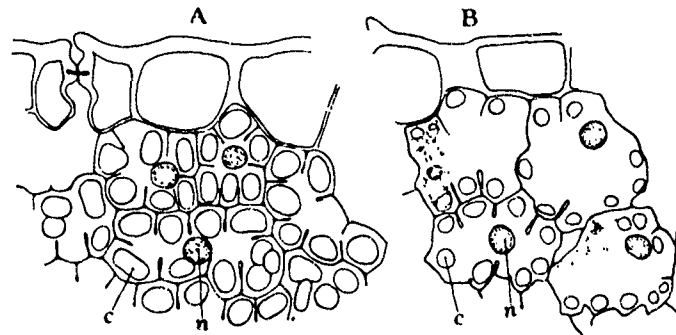

Figure 4:   A. normal   c. chloroplats   n.   nucleus
            B. Beginning of venenation
            C. Reduction of chloroplasts, disintegration in places. n. nucleus

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Beginning stage. A granular structure is frequently present. This is even more apparent in the sections outside of the assimilatory tissue. At first the chloroplasts become markedly deficient in chromatin and their outlines become very indistinct. Sometimes two or three adhere to each other and present a very irregular shape. Then the chloroplasts are rapidly reduced in number. In Togo /Japanese brand name/ for example, the size of a chloroplast in a normal leaf was 3.1 x 5 μ to 4.4 x 5 μ while in a venenate leaf the size was seen to diminish to 1.9 x 2.5 to 2.5 x 3.8 μ. The nuclei in most cases apparently do not change. (Fig. 2B, C; Fig. 4).

Terminal State. In further development, the existence of a few fresh hyphae is frequently observed inside the cells and the protopasm indicates granular and foamy disintegration (Fig. 3E and 5C). In extreme cases the cells become completely empty. Often dense infection granules become concentrated into grape-like globules. The nuclei at first are unchanged but sometimes they present a change in form. Often it later becomes difficult to detect their existence. The chloroplasts gradually lose their contents and finally only their positions are indicated by the existence of infection granules in places. (Fig. 3A, Fig. 5A). Later the existence of neither nuclei nor pigmentation can be observed and frequently the inside of the cells come to indicate a nearly homogeneous granular disintegration (Fig. 3B, C, E). The brown coloration of the cell walls is clearly observable in the rather markedly infected parts of the venenate tissue. This at first begins with coloration of the intercellular membranes and then the entire cell walls turn brown (Fig. 5).
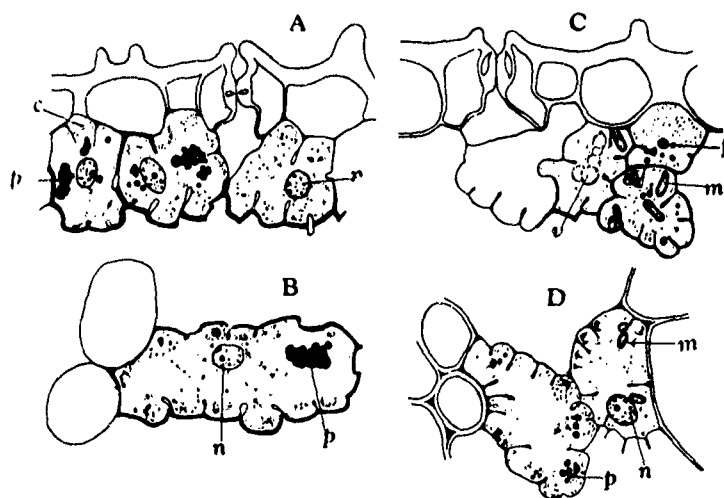
Figure 5: Terminal venenation period. Chloroplasts c
disintegrate and the cell contents present a
granular structure. Dense grape-like infection
granules p are seen. Wall coloration is pro-
nounced. In C there is a foamy, disintegrated
section v inside. The existence of hyphae m is
seen in C and D.

        To sum up the results of observation, rice-plant tissue
which has become afflicated with piricularia oryzae first presents
symptoms of venenation. That is, the pathogenes which have invaded
the tissues secrete some harmful substance which permeates the tissue
in an area as yet unaffected by the pathogenes and thus symptoms
of venenation are discovered in these areas. That is, first there
is a swelling of the protoplasm, reduction of chloroplasts, and
coloration of cell membranes, and then the cell contents gradually
disintegrate and are absorbed. Ito and Hayashi (4) claim that the
pigmentation in tissue which has suffered a mild attack of piricularia
oryzae first expands and is then reduced, but according to results
of observation there is no swelling of the pigmentation in the initial
stages of piricularia oryzae venenation, while there is a gradual
decrease in chromatin together with a gradual reduction in pigmen-
tation. It is difficult to say, however, whether there is any
change in the size of the nuclei.

        Thus, when the pathogenic hyphae, during the appearance
of symptoms of venenation, directly invade the cells and their
surrounding areas, the contents of the cells are gradually assimilated

and absorbed, the cells finally become empty, the deterioration of the cell membranes ceases and they are partially decomposed. That is, such tissue very rapidly changes from symptoms of venenation, to a necrotic, and soon after to a disintegrated state. Thus invasion of pathogenes is rather slight and venenation is not very severe, or the slightly infected portion, i.e., the vascular bundle or its neighboring tissue, depending on the location of the infected area of the host, indicates a necrotic condition for a long period. That is, as regards the reaction on the part of the host, of the damaged areas, the nuclei and chromatin which still remain in the infected tissue deteriorate markedly and become colored, together with the cell membranes and finally display a black-brown color when observed externally. This dark colored necrotic area later becomes decomposed further and reaches a state of disintegration but some of it may remain in the necrotic state.

      b. Piricularia Oryzae in Base of Ear.

      The region near the base of the ear of early Jinriki rice was inoculated with pathogenes at earing time, and according to results of observation of the initial stages in the invasion of those areas, affliction often at first commences from the rather soft stem epidermis near the node section or from the region of the tips of the scaly bracts. The tissue changes to a brown color and hyphae are seen in places. While the damage is first confined to the surrounding sclerenchymatous cells, the damage and withered area soon increases, finally reaching the assimilatory tissue and the fundamental soft tissue causing them to die. The cell membranes in the dead tissue turn brown.

      In those specimens which had not failed to ripen even though afflicted with the disease, the assimilatory tissue and fundamental tissue in many cases had been invaded, deteriorated, and the wall membranes turned brown, but invasion was checked by the vascular bundle sheath and the inside of the sheath was observed to be in perfect condition. Moreover, although damage was pronounced on one side of the stem, the other half was observed in many cases to be either slightly damaged or almost unafflicted.

      The results of observation of samples of inoculated late Jinriki (ear) bases and stems of natural, field grown Asahi which were afflicted with piricularia oryzae, and in which the degree of ripening was considerably lowered, are as follows:

Vicinity of center of stigmata. The assimilatory tissue completely disintegrated without leaving its shape behind. It changed to brown, became flat, and in many cases one cell became fused into another. The surrounding sclerenchymatous tissue left its shape behind and the existence of hyphae in the cells was obserbed. In the vascular bundle, the sieve tube section disintegrated becoming a large, empty hole. The sieve tube walls, companion cell walls, and the broken parts of walls of the surrounding parenchyma in places became fused together and remained and in many cases hyphae could be seen among them. New hyphae could be seen running vertically and horizontally in and outside of the lysigenous lacunae of the annular vessel section. The parenchyma around the vessels were often disintegrated. The vascular sheath had deteriorated and hyphae in not a few cases were detected growing inside the cells. Although in many cases the form of the fundamental parenchyma was preserved, the cell contents had disappeared and new hyphae were seen growing horizontally and vertically inside and outside of the cells. Thus it appeared that one part of the hyphae rapidly reached the medullary cavities.

The area somewhat distant from the center of the spotted section. The hyphae have become elongated in certain assimilatory tissue areas and sometimes one observes that an entire section of assimilatory tissue (in cross section) has turned brown. Sometimes, however, there has been no invasion whatsoever. The fundamental parenchyma often leave their shape behind and while it is sometimes possible to see hyphae running lengthwise inside of the cells, they are usually found running lengthwise through the gaps between the cells. On the whole, the vascular bundles do not display any irregularities. Sometimes there are many hyphae inside the reticulare vessels. In such a case they are seen not only in the case of the vessels but in the lysigenous lacunae of the annular vessel section. At times, even more severe damage can be seen in the sieve tube section. In these cases, hyphae are to be seen inside the cells of the vascular bundle sheath tissue as well.

In those portions where damage was very extensive and the ear became white, the fundamental parenchyma sometimes left behind its form and shape but most had disintegrated, and in a cross section view, hyphae were observed in a pronounced fashion running across the tissue.
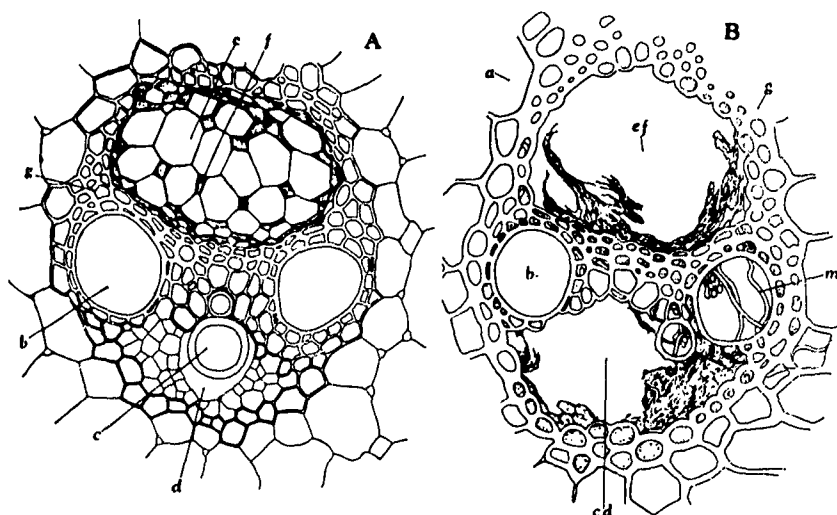
Figure 6. Inner vascular bundles
            A. Normal; B. Damaged.
            a. parenchyma; b. reticulate vessels; c. annular
            vessel; d. lysigenous lacuna; e. sieve tube;
            f. companion cell; g. vascular bundle sheath;
            m. mycelium:
            In B the vascular bundle sheath (g) and its interior
            tissue is severely damaged. The tissue in the
            annular vessel section (cd) and the sieve tubes (cf)
            have disintegrated forming a large hole.

Hyphae are seen in the medullary cavity, spreading inwards from the
surrounding walls in spiderweb fashion. The sclerencymae around the
stem and the inner vascular bundle sheath still preserve their form
but are completely devoid of content matter and hyphae can be seen
in its place. The disintegration of assimilatory tissue and the tissue
in the vascular bundle sheath is the same as described in the last
section above. Under such conditions of damage, the afflicated section
should gradually increase upwards or downwards until desiccated from
the vicinity of the center of the diseased area. Finally, the vertical
passage of water in the diseased area ceases, the ears will become
white before the spikes have a chance to mature, and those spikes which
have commenced the maturation period should finally show a marked lapse
in ripening.

While generally no great difference is seen between the case of infection of the base of the ear by piricularia oryzae and infection of the leaf, in terms of alteration of the cell interiors of the infected tissues, one especially outstanding difference in the infection of the base of the ear is the starch remaining inside the damaged fundamental tissue. That is, starch granules remaining inside the severely affected fundamental tissues are frequently still observed, although their number may have decreased somewhat.

The pathogenes which have invaded the stem section later damage its epidermis if the invaded tissue is soft, or basidospicae emerge into the outer part from the openings in the stomata, but usually it is apparently difficult for the spikes to emerge to the outside since the surrounding sclerenchymate which have developed under the epidermis are tough.

c. Disease of Node

As reported by Hayami Takeo in 1931 (1), piricularia oryzae in the node was detected in the node below the base of the ear, i.e. in the node of the cotyledon. Internal variation in the diseased area was observed not to be greatly different in general from piricularia in the base of the ear. However, one outstanding difference was the damage in the area attached to the leaf sheath. When damage was severe, the leaf sheath became separated at the lines of growth. However, the base of the stem around which this is wrapped shows a pronounced development of motor cells and even in severely damaged areas, separation from the node section is not observed. (Fig. 7A)

It seems that in node piricularia no harmful effects extend to the ears except when there has been considerable progress in deterioration. Now to sum up the results of observation of whitening of the ear due solely to piricularia infection of the node. The parenchyma in the vicinity of the lines of growth on the upper part of the stem which comes in contact with the infected node has decomposed completely over a broad area, leaving only the surrounding sclerenchuma and inner vascular bundle section. This area is easily compressed when pressed with the fingertip. Also, the tissue within the inner vascular bundle sheath was invaded extensively. Figure 7B shows one example of extensive infection by node piricularia. Generally the parenchyma is severely damaged, especially in the region of the cavity on the stem above the node. Infection is most severe at the base where contact is made with the sheath, and the cells have disintegrated, losing their original shape.

Figure 7: A. Distribution of the node of the vascular
bundle and motor tissue; a, b, c, d, vascular
bundle; e. medullary cacity; f. stem above
node; g. leaf sheath; h. stem below node,
black spots are motor tissue.
B. Diseased node; degree of infection shown
by density of black dots. /Translator's
Note: appearing as white dcts on the negative
photocopy of original./

        Also, in the bottom part of the node, extensive damage
is seen in the section towards the meduallary cavity. The center
section of the node, i.e., the region near the branching off point
of the vascular bundles is damaged rather slightly and does not
disintegrate, due to pronounced lignification after earing. The
areas outside of the center vascular bundle on the stem beneath
the node suffered slight damage.

III. Discussion

        Ikate (3) inoculated Sensho dry land rice, which has a strong
resistance to disease, with piricularia oryzae, and he discovered

the existence of many hyphae when he observed that there is a pronounced increase in chromatin in the invaded cells and that they have obviously died. He observed that these hyphae finally are unable to escape from the dead cells and that they consequently cannot invade inner tissue. In another of his observations, the pathogenes apparently invaded the motor cells and stopped inside those cells.

As already mentioned above (13), all the surrounding walls of the motor cells of the rice plant become silicified as the leaf grows. This silicification sometimes occurs in one or two of the center cells in the motor tissues. It has already been pointed out (8, 9) that the extend of silicification differs depending on the variety of rice and the conditions of cultivation. Ikata suggests in one of his observations, that the pathogenes which succeeded in invading those motor cells which were not yet highly silicified could not invade by penetrating the inner walls of the motor cells due to the gradual silicification of the latter, finally are forced to stop within the cells and then cause an increase in the deterioration of the cells. Thus, the protective action of silica is generally recognized when it prevents the invasion of piricularia oryzae through the epidermis. It has further been indicated by many (1, 3, 4, 5, 8, 9, 10, 11, 13) that invasion is difficult when there has been progress in silicification and toughening of the outer epidermal wall.

After pathogenic invasion, in the case of slightly venenated damaged tissue, a pronounced deterioration of remaining cell contents is observed together with the brown coloration of the cell walls of the damaged tissue. As far as this area is concerned, the invasion of the epidermal tissues and the necrotic areas in the assimilatory tissues work to resist invasion by all pathogenes; in other words, a type of suspicious lignification /sic/ of these tissues prevents an increase in the diseased areas. However, it is apparent that the suspicious lignification of the assimilatory tissue and fundamental parenchyma does not constitute a perfect healing layer. Thus, while such deteriorated tissue itself may have resistivity to pathogenic invasion, according to results of observation of cross and lengthwise sections, the spaces between the cells are usually empty and are not seen to be filled with resinous matter. Furthermore we apparently must not say that a substance causing the death of pathogenes from deteriorated tissues will be produced, and very often no change is observed in the hyphae inside of the damaged tissue. Therefore, the fungus not infrequently will leave this

deteriorated tissue and invade other areas provided that the conditions for the nutrition of these pathogenes are fulfilled and the proper temperature and water are provided.

After the pathogenes reach the interior of the vascular bundle, the increase in damage becomes very pronounced, long lengthwise stripes from a leaf and finally the leaf will wither and die. In such cases these same phenomenon can be observed when the stem section (except the vascular bundle) is attacked, in the damage done to the fundamental parencyma as well as to the medullary cavities. For this reason it is easy for long cylindrical spots to occur all around the stem. This is called "internal infection" by the author.

The motor tissue around the inner vascular bundle, i.e. the vascular bundle sheath, apparently resists pathogenic damage quite well, and in spite of the fact that the outer portion may be extensively infected, one frequently discovers that no changes have occurred in the tissues inside of the sheath. While affliction of the base of the ear may have progressed considerably and damage may be pronounced in the assimilatory tissue and fundamental tissue, sometimes no irregularity whatsoever will be detected in the tissue inside the vascular bundle sheath. Naturally, it is acknowledge that if such a condition is maintained, there will be no harmful interference to the ripening of the plant.

When the fundamental tissue in the stem section is normal, there is usually some reserve starch inside the cells. Thus one frequently sees a few cells in which grains of starch remain, even in tissue which has become extensively disintegrated due to invasion. Also, the frequency of occurrence and amount is usually very irregular. This is because according to the character of piricularia oryzae, cells are found which contain residual starch grains due (12) to the very low amyolysis capacity of starch sugar. On the other hand, the very iregular distribution of cells containing it and the general drecreases in starch is a result of a decrease in soluble sugar in the fluids in the host at the beginning of invasion by pathogenes (due to that used by the host when the pathogenes consume the sugar). The cells try to obtain a balance in content and since the reserve starch is converted to soluble sugar, a decrease in starch should thus occur. In this way severe deterioration occurs in the cells in which reserve starch remains, due to invasion, or the starch afterwards will not dissolve easily and finally will be retained as a residue.

IV. Summary.

A description has been presented above of the results of internal observations of infected leaf, base of ear, and node of a rice plant infected with piricularia oryzae after making external observations of the same areas.

Infection of leaf. The affected tissue was divided, according to severity of damage, into (1) disintegrated, (2) necrotic, and (3) venenate sections. The disintegrated section was found mostly in the center of the stigmata, the cell contents disappeared, the cell walls partially disintegrated, and the cells became flat as if compressed from both sides. A small number of coarse hyphae were found inside and many basidospicae emerged on the surface. The necrotic section was that area which appeared brown when viewed externally. If often was located around the outside of the disintegrated section or found surrounding the vascular bundle in the disintegrated section. The cell membranes, together with the remaining cell contents, turned a natural brown color and the amount of chromatin increased considerably. While there was generally a small number of hyphae in the necrotic sections they were often found in large quantities in the areas bordering the venenate sections. The venenate section, located around the outside of the necrotic zone is so called because it was that section in which no marked deterioration had taken place even though directly or indirectly invaded by pathogenes. When there were many hyphae inside the affected tissues, in some cases they were completely absent. The pathological changes in the venenate tissue are complex and are divided into initial and terminal stages.

To sum up results of observations on the above, the pathogenes which invaded the rice tissue secrete some harmful substance which permeates tissue near areas that are free of pathogenes and these areas thus come to indicate venenate symptoms. The protoplasm swells, the chloroplasts are reduced, discoloration occurs, and the cell membranes deteriorate. Finally the protoplasm indicates a uniformly granular or foamy state of disintegration. At such a time, the contents of the cells gradually disintegrate and become absorbed if the pathogenic hyphae directly invade the cell interiors or neighboring tissues. The necrotic state is passed very rapidly and the final, disintegrated state is reached. However, if the pathogenes do not invade too rapidly, or when venenation is not too severe on account of the location of the venenate zones, the nuclei in the afflicted tissues, the

chloroplasts etc. deteriorate, are colored extensively, and a necrotic zone should be formed which appears blackish-brown when viewed from the outside, i.e., this is a type of suspicious lignification. This section may later reach the deterioration stage or remain as is.

Base of Ear. Piricularia orzyae in most cases affects the base of the ear and the nodes of the spikelets when infection is seen in the stem at the time of earing. This is apparently due to the ease with which the pathogenic spores settle here due to the complex external shapes in this area. That is, there are complex shapes in this area such as scaly bracts, antler-like hairs, branching of spikelets, etc. Pathological changes in the internal tissue of the afflicted base of the ear generally are similar to those in the leaf, in this regard the author has described two sections: (1) the area near the center of venenation and (2) outlying areas, somewhat separated from the former.

In those areas which turned white /literally; become "white-ears"/ due to severe affliction, the parenchymae were extensively disintegrated near the center of the stigmata and hyphae could be seen running among them lengthwise and across. In the medullary cavities, the hyphae elongated from the surrounding walls in spider-web fashion. The sclerenchymaea around the stem and the inner vascular bundle sheath still retained their shape but lost their contents and hyphae could be observed in the inner cavities. The tissues in the sheath were severely damaged. On the other hand, in those areas of the base of the ear which were affected by piricularia but in which little effect was seen on the ripening of the ears, the interior of much of the inner vascular bundle sheath usually remained healthy regardless of the damage done to the assimilatory and fundamental tissue of the base of the ear.

Node Section. This is the section immediately below the ear base, i.e., the cotyledon section, in which damage was often severe. While pathological changes in general were identical to those in the base of the ear, the leaf sheath should be somewhat detached near the lines of growth when damage is extensive. In those portions in which the ear turned white due to infection only by the node section, the inner tissue of the stem above the node was extensively disintegrated, leaving behind only the skeleton of the inner vascular bundle and the sclerenchymaea of the surrounding walls.

One of the most outstanding features in diseased tissue in the stem section is the existence, in spots, of grains of starch inside the damaged tissues. This is believed due to the weak amylolysis capability owing to the nature of the pathogenes.

In closing this paper, the author wishes to express his sincere gratitude to professor Nakada Kaugoro of the Faculty of Agriculture of Kyushu Imperial University for his teaching and to technician Takeuchi Haruyoshi of the agricultural experiment station of Fukuoka Prefecture, Mr. Kawamura Eikichi of the Faculty of Agriculture at Kyushu Imperial University, and to Mr. Takimoto Seito of the same University for providing him with instruction and materials.

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SUMMARY

A description has been given of some histological observations of the diseased tissues of the leaf, base of ear, and nodes of adult rice plants affected by Piricularia Oryzae. From observation it was possible to divide the diseased portion of an affected leaf into three zones: venenate, necrotic, and disintegrated.

In the leaf, the center of the stigmata (spots) was usually disintegrated. This disintegrated area was surrounded by a brown necrotic zone which in turn was bordered by the venenate area. The cells in the disintegrated zone were flat, empty, and contained a few coarse hyphae, while in the necrotic zone there was a considerable increase in the amount of chromatin and the cells were brown. The venenate area, although invaded by pathogenes, did not suffer any extensive damage, the complex process of venenation is divided into initial and terminal stages.

The base of the ear is affected when infection is observed in the stem at the time of earing, apparently because of the complex structures in this area (scaly bracts, branched spikelets, etc.) which trap the pathogenic spores. In the disintegrated and necrotic areas there was considerable invasion of hyphae while the interior of the vascular bundle sheath in those areas where the ripening of the ears was little affected remained healthy although the assimilatory and fundamental tissues were damaged.

The node section, which is immediately below the base of the ear, suffered rather severe damage. While pathological changes generally were identical to those in the base of the ear, the leaf sheath was found to be slightly detached near the lines of growth when damage was extensive. In the areas of the ear which turned white due to infection from the node section, the inner tissue of the stem above the node was disintegrated to a considerable extent.

An interesting phenomenon observed was the existence of reserve starch inside some of the damaged tissues of the stem, believed due to the relative inability for amyolysis to take place owing to the nature of the pathogenes.

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